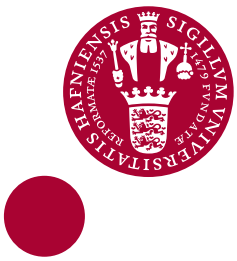


What do we know about explanationsfor drop out/opt out among young people from STM higher education programs?

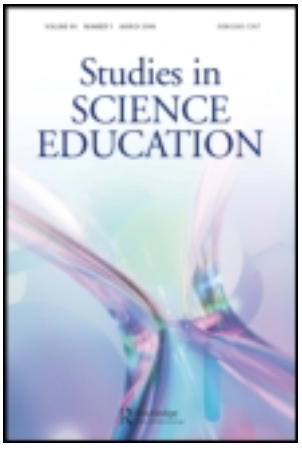
Ulriksen, Lars; Madsen, Lene Møller; Holmegaard, Henriette Tolstrup

Published in:
Studies in Science Education

Publication date:
2010

Document version
Early version, also known as pre-print

Citation for published version (APA):
Ulriksen, L., Madsen, L. M., & Holmegaard, H. T. (2010). What do we know about explanationsfor drop out/opt out among young people from STM higher education programs? *Studies in Science Education*, *46*(2), 209-244.



Studies in Science Education
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/rsse20

What do we know about explanations for drop out/opt out among young people from STM higher education programmes?

Lars Ulriksen [a], Lene Møller Madsen [a] & Henriette T. Holmegaard [a]

[a] Department of Science Education, University of Copenhagen, Copenhagen, Denmark

Published online: 08 Sep 2010.

To cite this article: Lars Ulriksen , Lene Møller Madsen & Henriette T. Holmegaard (2010) What do we know about explanations for drop out/opt out among young people from STM higher education programmes?, Studies in Science Education, 46:2, 209-244

To link to this article: http://dx.doi.org/10.1080/03057267.2010.504549

Studies in Science Education
Vol. 46, No. 2, September 2010, 209–244

Routledge
Taylor & Francis Group

What do we know about explanations for drop out/opt out among young people from STM higher education programmes?

Lars Ulriksen*, Lene Møller Madsen and Henriette T. Holmegaard

Department of Science Education, University of Copenhagen, Copenhagen, Denmark

In this paper we provide an overview of the literature on understandings of drop out/opt out from science, technology and mathematics (STM) higher education programmes. After outlining the literature on students leaving higher education programmes in general, we then explore the research on drop out/opt out from STM programmes in particular, with an emphasis on research since 2000. We show that most of the research focuses on overcoming deficits in students' prior knowledge, but that a more specific focus on identities as an analytical framework for understanding young people leaving STM higher education programmes is also emerging. We show that it is important to shift from considering drop out as an individual problem for the student to regard it as a feature of the relationship between students and their study programmes. In the same way, measures to increase retention rates must shift from focusing on individual student adaptation to studies addressing institutional change. However, this change is difficult since it is entwined with fundamental conceptions of science and teaching.

Keywords: retention; STM higher education; drop out; academic and social integration; identity; individual adaptation; institutional change

Introduction

According to statistics from the Organisation for Economic Co-operation and Development (OECD), one-third of higher education students drop out of their studies before they complete their first degree (averaged across all OECD countries and all subjects), regardless of whether they are following university level education (tertiary-type A programmes) or vocationally oriented tertiary education (tertiary-type B programmes) (OECD 2009, p. 69ff). However, this average hides variations between countries with some countries showing a survival rate of less than 60% (e.g. Italy, Sweden) and others more than 80% (namely Belgium (Flemish Community), Denmark and Japan). These numbers are for 2007 and refer to the estimated percentage of the age cohort that will complete tertiary-type A/B education (OECD, 2009, p. 72). The report also states that these educational systems have expanded significantly, with nearly twice as many people graduating from university in 2007 than in the mid 1990s.

The term 'drop out' is commonly used to describe those students leaving their study before they pass the final examination. The loss of students from science, technology and mathematics (STM) studies to other careers has been described as a 'leaky pipeline'. However, as pointed out by Hovdhaugen (2009), different designations are

*Corresponding author. Email: ulriksen@ind.ku.dk

ISSN 0305-7267 print/ISSN 1940-8412 online

DOI: 10.1080/03057267.2010.504549
http://www.informaworld.com

used within distinct research settings: 'In the USA, the phenomenon is described as "dropout" or "student departure" while British researchers usually use the concept "non-completion" or "non-continuing students"' (Hovdhaugen, 2009, p. 2). These different expressions reflect whether we interpret students leaving an educational programme as a push or a pull effect and for whom it is a problem.

Another issue discussed by Hovdhaugen (2009) is that even if a high percentage of university students leave their initial institution before degree completion, the majority of these leavers transfer to another higher education institution, resulting in a smaller percentage of the students leaving higher education without completing a degree at all. Reflecting this distinction within non-completion rates, Tinto suggests identification of 'institutional departures' (students transferring from one higher education institution to another), and 'system departures' (students leaving the higher education system altogether) (Tinto, 1993, p. 36).

That almost a third of students do not complete their degrees must be considered a challenge and a problem for students, higher education institutions and society as a whole. Drop out in relation to STM studies presents a particular reason for concern. Since there seems to be a general agreement in the Western countries that there is a need for an increasing number of graduates in this field, some attention has been given to raise the recruitment of students (OECD, 2008). However, according to the OECD study 'in many countries, S&T [Science and Technology] are among the disciplines where the dropout rates are the highest', with science suffering more than technology (OECD, 2008, p. 74). A study of non-completion in Germany found that of the students entering the sciences in 1999–2001, 28% did not complete their studies, with some differences between the disciplines. Physics and earth science, computer science (in German: *Informatik*), mathematics and chemistry lost from 31% to 36% of students, while pharmacy, biology and geography lost only from 6% to 15% of students. Engineering had a non-completion rate of 25%, ranging from 16 to 34% depending on the discipline (Heublein, Schmelzer, & Sommer, 2008, p. 10f). Even if students of the humanities drop out at a similar rate (27%), losing almost 30%, and for some studies more, of those following STM courses, is a major concern. Students not completing their studies is therefore both of interest to the educational system in general and to the field of STM in particular.

In this paper[1], we address how research has tried to explain and understand the issues related to students leaving higher education programmes with a specific focus on STM programmes. Some of the research deals with retention and non-completion in general while other research focuses specifically on the STM field. By combining both research on higher education in general and STM in particular, we seek to extend and combine knowledge beyond the existing literature. To address this, the paper is organised as follows. First, we provide a short description of the procedures followed in the literature review. Second, we outline how the literature has examined drop out/opt out in higher education in general. The third and main part of the paper addresses these issues within an STM context. Here, we present an introduction and overview of the concept of 'identity' as a way forward in researching these matters. Finally, we discuss the implications of this review, and particularly the differences between considering drop out/opt out as either a question of individual adaptation or institutional change.

The aim of the review is to explore whether research on retention and non-completion in higher education, and in STM programmes in particular, has produced findings that can identify a direction forward for HE institutions and programmes to take

measures to reduce the number of students leaving their chosen HE programme. As a part of this discussion, we seek to point out issues and themes that call for further research and development. The review therefore will be of interest to teachers, planners and researchers of STM programmes in higher education.

Methods

The first section of the review deals with the general trends within higher education. This section takes as its point of departure the works of Pascarella and Terenzini (2005) and of Harvey, Drew, and Smith (2006). These two works provide extensive presentations of mainly US and UK based research respectively on persistence and non-completion in general, not focusing on the field of STM in particular. A seminal contribution, particularly in the US context, but also influencing European studies, is the work of Tinto (1975, 1988, 1993), and therefore this work is given some attention.

The second section of the review focuses on STM education in particular. The starting point for this part of the review is Seymour and Hewitt's book *Talking about leaving* published in 1997. To supplement this work, the rest of this section follows from a literature search using the ERIC (Education Resources Information Centre, http://www.eric.ed.gov/) database. Here the search words: science education and higher education are combined with the following words: retention, dropout, opt-out, persistence, student success, attrition, leaving and non-completion within the timeframe of 2000–2009.

Leaving higher education

In this section, we take as our starting point two extensive reviews, one emphasising US studies (Pascarella & Terenzini, 2005) and the other with a stronger focus on UK research (Harvey et al., 2006).

Examining the US-based research on retention and non-completion reveals a strong emphasis on quantitative studies. Most of the research reported is characterised by correlation and factor analyses on large samples of students. A smaller number of studies explore the qualitative aspects of students' experiences and non-completion. An important factor regarding non-completion appears to be the parents' educational background. Pascarella and Terenzini present a number of studies that confirm that students whose parents have earned a bachelor degree are more likely to pursue and complete a bachelor degree than first-generation students, commenting that for first-generation students 'going to college can be a difficult choice and experience, threatening to both them and their parents' (2005, p. 434). Whether one's parents have a degree or not turns out to have a stronger influence than factors such as race-ethnicity, family income, college qualifications or other factors associated with educational attainment (Pascarella & Terenzini, 2005, p. 435).

However, the effect of different factors seems to vary over time as suggested by Ishitani (2003) and DesJardins and Moye (2000). Both these studies use the event-history approach pointing out that the risks of leaving college vary over time. For instance the risk of first-generation students leaving college is higher in the first year than in the fourth year (Ishitani, 2003). Thus, measures that might be taken to diminish risks should take these timing effects into consideration.

DesJardins and Moye (2000) find an increased risk of not graduating associated with membership of an ethnic minority group, but this effect becomes less strong

when financial aid and grade point average (GPA) are controlled for. Considering the impact of financial aid, they find that, in general, loans enhance graduation probability, but this relation becomes less pronounced as time passes. Conversely, work/study initially inhibits timely graduation, but around year 6 this reverses (DesJardins & Moye, 2000, p. 16). Tinto remarks that if properly organised and within limits, work-study programmes can enhance the chances of persistence because they not only improve the financial situation of the student, but also help the student to establish contact with other members of the institution. On the other hand, there is a risk that the work will isolate the student from life at the institution or take up too much time (1993, p. 179f).

In a large scale event history analysis based on national statistics, DesJardins and Moye find that males are more at risk of not completing than females (2000, p. 18). The review by Harvey et al. (2006) reaches the same conclusion, while Ishitani, analysing survey data of 1747 students in a Midwest four-year university, concludes the opposite, but only significantly for academic years 3 and 4 (2003, p. 444). Mastekaasa and Smeby (2008) find no clear pattern in the dropout rates for male and female students in the research they have reviewed in their work. It is highly probable that these apparently contradictory findings related to gender and retention reflect the diversity of the academic field and to the complexity in how student background (as, for instance, gender, ethnicity and socio-economic status) interacts with different environments and cultures. As we will explore further in the section on identity later in this paper, the different student characteristics intersect, and rather than being either 'male' or 'female', students negotiate and interpret what these labels mean, just like the kinds of study practices and interests they leave room for varies across the academic field. Different disciplinary and institutional cultures are more or less inclusive to different ways of being a student, which could explain the ambiguous evidence on the matter. Distinctions of this nature are difficult to grasp in large scale primarily quantitative studies that go across different disciplines.

Tinto's model of student leaving

A substantial part of the studies reviewed by Pascarella and Terenzini (2005) are strongly influenced by the work of Vincent Tinto (1975, 1988, 1993). This work has achieved an almost paradigmatic stature (Braxton, Milem, & Sullivan, 2000). Tinto's model (1975, 1988, 1993, 1998) emphasises that students leaving university should be regarded as a process. Students enter with a set of pre-entry attributes, and these attributes produce a set of goals and commitments that the students bring with them as they enter university and engage in the social and academic environment at that institution.

Tinto criticises psychological approaches to understanding students leaving college because they tend to focus on traits of the individual, thereby making student success dependant on 'the ability or willingness of the individual' and 'more important, such models invariably see student departure as reflecting some shortcoming and/or weakness in the individual', and thus as the result of personal failure (1993, p. 85). Instead, Tinto emphasises a more sociological approach focusing on the level of the institution. Though previous sociological approaches to the study of retention provide relevant insights, Tinto claims that they tend to leave the actual interaction between students and institutions almost untouched (ibid., p. 86ff). It is precisely this level – the students' interaction with the institution and how this influences student

persistence – that is his primary interest. The student's involvement leads to some degree of social and academic integration that again produces a set of goals and commitments that lead to a decision to depart from or stay at university. In the 1993-version of the model, the process at university is 'nested in an external environment comprised of external communities with their own set of values and behavioural requirements' (ibid., p. 115). Thus the university is a social system that works within a set of other social systems, and the students are simultaneously engaged in more systems.

In the development of the model, Tinto takes inspiration from two sources. The first is a socio-anthropological theory of rites of passage by Van Gennep that describes the transition from one culture to another as a process of leaving one and becoming integrated in another culture. This transition has three stages: separation, transition and integration. The second is Durkheim's theory of suicide where suicide *inter alia* is understood in relation to the (lack of) social and intellectual integration in society. Tinto compares these elements of passages and integration to an academic and social integration at college (Tinto, 1993). The academic integration primarily refers to those parts of university life that are related to the formal education and to the student learning in the study programmes. This mainly takes place in classrooms, lecture halls and study groups. The social integration refers to the student's interaction in informal parts of university life such as unions, cultural gatherings and informal contact with teachers outside of the classroom.

Comparing the 1975 version of the model with the one from 1993, the student's interaction with staff/faculty has moved from the social system to the academic system, acknowledging that academic integration is not simply about performing well, but is also a matter of interacting with teachers. However, the academic and the social system of the college are regarded as two distinct, but *'invariably interwoven'* systems (1993, p. 109).

Importantly, Tinto also makes the point that the university consists of more than one culture – that there are subcultures, and that students may become integrated in one of these, but not in the dominant culture (ibid., p. 105). These two points, namely, firstly, that the social and the academic systems are interwoven, and therefore influence each other, and secondly, that universities consist of more than one culture, brings Tinto to emphasise educational communities in the classrooms as an important arena for the integration of students at university. This is certainly important for non-residential students where the social integration to a large extent has to occur during class or in relation to class activities (ibid., p. 206, and Tinto, 1997, 1998). In his concluding remarks he states that an institution's capacity to retain students:

> …hinges on the establishment of a healthy, caring educational environment which enables all individuals, not just some, to find a niche in one or more of the many social and intellectual communities of the institution. This view of the effect of institutions upon student leaving highlights the intricate web of reciprocal relationships which binds students to the communal life of the institution. Rather than single out any one action or set of actions as being the primary cause of student departure, it argues that student leaving is affected by most institutional actions regardless of their immediate referent. (Tinto, 1993, p. 204f).

Tinto's model has several virtues. One is that it regards student leaving as a longitudinal process that involves more than one factor. Another is that it includes both the social and the academic aspect of students' integration.

Evidently, holding an almost paradigmatic position does not mean that Tinto's model of student leaving is uncontested or uncriticised. At one level, it has been questioned whether the claims of Tinto can be substantiated by empirical findings, and on another, it has been argued that Tinto's use of Van Gennep and Durkheim leads to a lack of sensitivity towards especially ethnic minority students' situation in higher education, as explored below.

In their review, Pascarella and Terenzini state that they can find 'moderate' support for the 15 claims they make out of Tinto's model (Pascarella & Terenzini, 2005, p. 425f and 443f). However, as noted by Pascarella and Terenzini, a review by Braxton, Sullivan, and Johnson (1997) reports only 'partial' support for some, and 'frail' support for others of the 15 claims. Based on this, the authors do not recommend abandoning, but revising the model (Braxton et al., 1997, p. 156). Still, the importance of being integrated into the university community is echoed in other findings in the US review.

This is certainly the case when Pascarella and Terenzini report that different programmatic interventions such as supplemental instruction and first-year seminars have an impact on student persistence (Pascarella & Terenzini, 2005, p. 398ff). However, they point out that the dynamics beneath this success are unclear, for instance whether the impact is direct (that is, that the skills developed etc. increases student persistence) or indirect (for instance earlier socialisation into the university culture and increased interaction with faculty, staff and peers) (ibid., 2005, p. 403). Likewise, they find that different experiential and inquiry-based learning approaches increase rates of persistence, not least due to the student–faculty contact and active learning involved (ibid., 2005, p. 406). Similar findings are reported by Braxton et al. (2000), who find that active learning activities have a positive influence on student persistence, and *inter alia* on social integration, and they make the point that 'faculty classroom behaviours play a role in the student departure process' (p. 581).

Another aspect is the importance of interaction with faculty members outside of the classroom. This has an impact due to the process of socialising the students to values and attitudes in the academy, and also due to students creating a stronger bond with the institution (Pascarella & Terenzini, 2005, p. 417); or as Tinto (1993) phrases it, their institutional commitment. This effect is to a large extent based on students' perception of faculty members' availability and concern for the students. Along similar lines is a meta-analysis of nine studies in STM courses that found a positive effect for the persistence of students who were involved in cooperative and collaborative learning activities (Pascarella & Terenzini, 2005, p. 423; cf. Braxton et al., 2000).

On a theoretical level, Tinto has been criticised for making general claims from a model that may only fit some groups of students (Pascarella & Terenzini, 2005, p. 56). Hurtado and Carter (1997), studying experiences of Latino students' sense of belonging at university, state that Tinto's model does not take the importance of racially tense environments at universities into account. According to Tierney (1999), Tinto's model implies that minority students, or students who in other ways differ from the dominant majority culture, should undergo a process of assimilation. Tierney argues that these implications of Tinto's work follow from the theoretical foundations of the model on Durkheim's study of suicide and Van Gennep's of initiation rites, implying that 'the success of the initiates – that is, the students – being dependent upon the degree to which they are able to integrate into the social and academic life of postsecondary institutions' (Tierney, 1999, p. 82).

Tierney argues that the use of Van Gennep is dubious as the theory relates to initiation rites *within* a culture, albeit at different stages, while minority students entering universities in effect are entering a culture that is different from their own. Likewise, the application of Durkheim's theory of suicide implies a cruel fate for minority students who, as Tierney puts it, must commit 'a form of cultural suicide' (1999, p. 82). Therefore, the consequence of the model is that minority students must discard aspects of their cultural background in order to succeed at university. Tierney argues that this contradicts experiences from his own research with students of colour, which conversely indicates that precisely the inclusion of the family and the neighbourhood of the minority students has been shown to increase students' sense of belonging at university, and in that sense the social and academic integration.

Hurtado and Carter similarly found that for Latino students at predominantly white universities it had a positive impact on their feeling at home at the university to maintain interactions both inside and outside campus (1997, p. 338), as did participation in some culturally related activities such as association with social-community organisations and religious organisations (ibid., p. 335). For these students it is not simply a question of being integrated or not, but rather preserving a relation to multiple peer-groups and cultural environments.

Undoubtedly, there is a risk of the notion of social and academic integration to be interpreted simply as assimilation, and that measures taken by the institutions to prevent non-continuation could overemphasise that students should conform to the dominant culture. The research reported by Tierney and by Hurtago and Carter indicates that this could be detrimental to the persistence of minority students. Therefore, it is critically important to be aware of whether support activities and structures at universities acknowledge these differences or not.

On the other hand, the question is whether this in effect is an integrated part of Tinto's model. In our view, this partly depends on whether the model is read as a normative or an analytical statement. In the 1993 version of the model, Tinto identifies some limitations in using the analogies of the initiation rites and of egotistical suicide on entering university (1993, p. 104ff). Likewise, he emphasises that 'the great majority of colleges are made up of several, if not many, communities or "subcultures," each with its own characteristic set of values and norms' (ibid., p. 105) and that for some students 'events external to the college play an important role in community membership' (ibid.). More importantly, what permeates the model is that attending university is a process of socialisation, and as such it is to be regarded as an interactional process between what the students bring with them and the culture they meet. Furthermore, this socialisation does not limit itself to academic features, but affects the tastes and practices of students in a broader context (Huber, 1991). Similar observations are made by Becher (1989, cf. Becher & Trowler, 2001) who – even if his study concerned research communities and not specifically student communities – points at the different cultures (or tribes as he calls them) that exist within academia, and which students need to gain access to (cf. Gerholm, 1990). For students at bachelor level, Hasse (2002), in her study of first-year physics students at a research intensive university, highlighted that becoming a physics student is more than merely learning the content knowledge; it is a matter of acquiring the right poise, or 'sprezzatura' as she calls it with reference to Italian courts. Conceiving studying as a process of socialisation also partly explains the previously mentioned importance of interaction with faculty members outside classroom. Such an interaction has an impact due to the process of socialising the students to values and attitudes in the academy.

Tierney (1999, p. 83) suggests the transition to university can be analysed and comprehended using the work of French sociologist Pierre Bourdieu and his concepts of capital and habitus (Bourdieu, 1984, 1986). Bourdieu argues that we bring with us a set of dispositions when we engage in social interactions, and these dispositions guide how we interpret and make sense of what we experience:

> The habitus is necessity internalized and converted into a disposition that generates meaningful practices and meaning-giving perceptions; it is a general, transposable disposition which carries out a systematic, universal application – beyond the limits of what has been directly learnt – of the necessity inherent in the learning conditions. (Bourdieu, 1984, p. 170)

Our habitus provides us with ways to make sense of what we encounter, to interpret it, and it provides a way to act in the social fields that we are part of, a practical sense. Since the habitus is formed by conditions of living, it has both an individual and a collective dimension. It is particular to the individual, but collective because it relates to material conditions and practices that are shared by other members of a social class.

When students enter university, they possess an amount of different types of capital to invest in the struggle to find a position in the social field she or he is entering. Two of these forms of capital are labelled 'the social' and 'the cultural'. The social capital refers to for instance networks and relations, while the cultural capital can exist in three forms, namely 'in the embodied state, i.e., in the form of long-lasting dispositions of the mind and body; in the objectified state, in the form of cultural goods […] and in the institutionalized state', which not least refer to the formalised educational qualifications (Bourdieu, 1986, p. 243). The embodied capital is 'converted into an integral part of the person, into a habitus' (ibid., p. 245).

A particular habitus can be more or less appropriate for engaging in the social practice of different fields depending on what counts as valuable in the given field. Similarly, some compositions of social and cultural capital are more profitable for establishing and maintaining a position in the educational field of university. Students entering higher education from a background that is socially and culturally remote to the academic field will therefore be more likely to have a habitus that makes it more difficult for them to understand how to play the game in the academic field, and to take part in this game. Presumably, the process of social and academic integration will be more laborious and challenging for students with non-academic backgrounds than for students whose parents hold a degree.

From the perspective of Bourdieu, it could be questioned whether Tinto entirely acknowledges the complexity of the process of transition and integration that minority students face when they try to find their way through the first years of college with cultural and social capital of limited value in the university field. Further, it could be questioned whether he fully acknowledges the resources present in the cultural (as posited by Tierney) and social (as pointed out by Hurtado and Carter) capital students possess – that these possessions could be transformed into resources that students could invest to increase the probability of persistence.

It may be true, that the model of Tinto – at least in the way it has been received – too strongly emphasises the integration into the dominant culture, where the capital students bring with them has little value. However, from the perspective of Bourdieu, we would argue that Tierney and Hurtado and Carter underestimate the significance

of the power dimension and the struggle for positions in the field of academia (cf. Bourdieu, 1990).

It appears convincing that facilitating subcultures at university that could provide a sense of belonging for students who do not feel related to the dominant social and academic culture at the institution, or whose academic aspirations do not necessarily concur with the dominant academic orientations and paths, could increase the persistence of these students. In that sense, not conforming with the dominant culture apparently is a viable way for non-traditional students to survive at university. However, even if the institutions involve themselves in facilitating religious or cultural organisations and institutions at campus, the stance of the institution would still be ambiguous. In his study of the academic field, Bourdieu remarks that the habitus of those holding the dominant positions in the field serve to select those who are to be included and exclude others:

> What may appear as a sort of collective defence organized by the professorial body is nothing more than the aggregated result of thousands of independent but orchestrated strategies of reproduction, thousands of acts which contribute effectively to the preservation of that body because they are the product of the sort of social conservation instinct that is the *habitus* of the members of a dominant group. (Bourdieu, 1990, p. 150)

The socialisation of new students at bachelor or PhD level therefore is not simply to ensure the academic qualification of the newcomers, but rather to make certain that the new members comply with the existing dominant culture. Therefore, when Tierney states that 'educational organizations must also accommodate for and honor students' cultural differences' (1999, p. 83), this may be true if those organisations have an interest in increasing student completion; but from the perspective of the organisations' struggle for position in the academic field, this is not necessarily the case. The interests of the universities are in these cases – from a Bourdieu perspective – at least ambiguous.

This also has significance for some of the measures that have been taken to ease the way for minority students at universities. As indicated by both Tierney and Hurtado and Carter, studies of minority students suggest that for those groups of students to succeed it may be a more viable path to establish subcultures that value the social and cultural capital of the minority. However, following the analysis of Bourdieu, this may well increase the probability of their completing their studies, but it is likely that it will also have the consequence that they are never fully integrated and accepted in the core of the academic community. This should not be an argument for giving up strategies like the ones suggested in Tierney's study, or for calling for a total assimilation in the white, dominant culture. On the other hand, it seriously questions the impact of targeted sub-cultural services and offers on students obtaining equal possibilities in the academy.

In our view Tinto provides an approach to student retention and leaving that focuses on student departure as a process involving students coming to terms with both academic and social aspects of university life. Consequently, integration becomes a pivotal concept. Furthermore, both Tinto's remarks on the multiple communities and subcultures at university, and the critical comments, from amongst others Tierney and Hurtado and Carter, emphasise that the process of integration is a complex one in which the differences in students' background, the composition of capital, the universities' level of inclusiveness and the position in the academic field all influence the students' expectations of success.

The importance of teaching and learning activities

In their review, Pascarella and Terenzini make a strong case that teaching–learning activities involving more student–staff interaction have a positive effect on student retention. Similar points are made in UK research on retention and students' first-year experiences as presented in a review by Harvey et al. (2006). Their review focuses on the first-year experience, but since the literature on withdrawal and retention of first-year students is significant (2006, p. 31), their review provides a valuable introduction to the mainly UK-based research. They note that the majority of the studies they have reviewed are based on single institutions and often with small samples. The research is dominated by quantitative studies although qualitative approaches are becoming more common (ibid., p. 14). They also comment that the US research in the field is highly influenced by Tinto's model of student leaving, and the issue of social and academic integration (ibid., 2006, p. 31), while research in the UK has focussed more on preparedness (including choice of study, expectations and being motivated) and student satisfaction (ibid., p. 37).

Harvey et al. remark that the literature presents an array of different explanations for retention or non-completion 'but none is sufficient and there is no simple sociological or psychological model of retention' (ibid., p. 33). Based on both a review of existing research, mainly from the UK, and their own rather large empirical studies, Yorke and Longden (2004) summarise four main categories of reasons for students leaving their study programmes:

- flawed decision-making about entering the programme;
- students' experience of the programme and the institution generally;
- failure to cope with the demands of the programme; and
- events that impact on students' lives outside the institution. (Yorke & Longden, 2004, p. 104)

The first point is supported by Ozga and Sukhnandan (1998) who conducted a qualitative study at a single UK campus university in the mid-1990s comprising of interviews with 20 withdrawers and eight students who completed their courses but who had seriously considered leaving. Ozga and Sukhnandan note that students tend to have a rather poor and frequently stereotypical and outdated knowledge of what attending university means, what kind of effort is required etc. (1998, p. 321). This seems to be the case both for those students who leave and those who stay, but those who stay have made a more pro-active choice of the course and of attending university, while non-completers entered because of expectations from family, peers or others, or because it seemed like the natural thing to do. This does not mean that students whose parents have a bachelor degree necessarily are worse off than first-generation students. It may be that the family pressure or the lack of reflection can be more pronounced in some of the families where the parents have attended higher education, but what the finding of Ozga and Sukhnandan does point out is that even if the socio-economic background of the students ought to put them in a better position to complete a degree, this is still uncertain if the choice is made without any significant intrinsic interest or educational commitment.

The importance of the socio-economic conditions is suggested by another of Ozga and Sukhnandan's (1998) findings, namely that the reasons for non-completion differ between mature students and what they call conventional students. Conventional students are mainly influenced by their preparedness and the compatibility of

choice, while mature students are more influenced by external factors, such as family obligations.

It is a general and important point made by Yorke and Longden (2004), and shared by Harvey et al. (2006), that rather than focusing on retention, institutions (and others) should focus on what could be done to enhance student success, hence taking a student-interest focus rather than applying an institutional-interest focus. As they put it: 'A policy focus on student success in higher education through teaching, learning and assessment, and through institutional support services, is likely to lead to better retention than a focus on retention itself.' (Yorke & Longden, 2004, p. 132).

The point is not only that focusing on teaching, learning and assessment addresses the second and third of the four bullet points above, but also that students' performances in the first year are highly influential on their persistence. Pascarella and Terenzini claim that 'college grades may well be the single best predictors of students persistence, degree completion, and graduate school enrolment' (2005, p. 396), and measures taken to improve student performance therefore are likely to improve persistence as well. What is more, attention to students' experiences in teaching and learning could also affect their notion of being integrated in (one of) the university culture(s).

Main points from this review of general studies of retention and non-completion

Research into retention and non-completion draws attention to the teaching and learning activities; to the students' experiences of success and of being able to cope with the requirements; and not least to the interaction with teachers and teaching methods that support the social and academic integration. The students' socio-economic background is definitely of importance, but not only due to the difficulties in meeting the economic demands of attending university. Also the culture (or *habitus*) of the students plays a pivotal role for students' social and academic integration.

Therefore, some of the findings point at factors that cross disciplinary boundaries and particularities of specific fields or disciplines like STM. On the other hand, the findings also suggest that there may be differences across disciplinary fields simply because the socialisation and the culture play such vital roles. In this perspective the research on retention in general not least underlines that close attention should be paid to both the academic culture of STM programmes and to the teaching and learning activities the students are presented with, especially during the first year of study.

Leaving STM higher education courses

Results from the 1990s: Seymour and Hewitt

> Switching is not defined as a problem when it is believed to be caused, on the one hand, by wrong choices, under preparation, lack of sufficient interest, ability or hard work, or on the other, by the discovery of a passion for another discipline. (Seymour & Hewitt, 1997, pp. 391–392)

As stated in this citation, it is necessary to establish an acceptance of a problem in order to address it. This is also true for the issue of students leaving the STM educational programmes. As discussed in Seymour (2002), the early days of research within this field were dominated by the above views of the situation, namely that it was the

students who were the problem. However, in their analysis of 335 STM students at seven different types of institutions in a four-year ethnographic study in the US, Seymour and Hewitt (1997) found that there was no evidence for those beliefs. On the contrary, their study showed that the most common reasons for students to switch higher education programme arose in response to a set of common problems experienced by both switchers and non-switchers. They did not, as Seymour puts it in a later article, 'find switchers and non-switchers to be two different kinds of people: they did not differ by performance, motivation or study-related behaviour to any degree that was sufficient to explain why one group left, and the other group stayed' (Seymour 2002, p. 82).

One difference they did find between switchers and non-switchers was that the intrinsic interest related to the major they had chosen and to the nature of the academic work was stronger among the non-switchers. Both groups were influenced by other factors as well, for instance the influence of others, but Seymour and Hewitt conclude that these other reasons seemed to be of less importance 'so long as one strong element in their decision is an intrinsic interest in the academic disciplines which comprise the major and in the kinds of work to which they lead' (1997, p. 78) (cf. the findings of Ozga and Sukhnandan (1998) mentioned above).

On the whole Seymour and Hewitt found more similarities than differences between the switchers and the non-switchers. There is a high level of agreement across the whole student sample about the issues that lead to defection by switchers and to dissatisfaction among non-switchers, and there are strong similarities in the importance members of each group ascribe to each set of concerns. They further found that:

> The decision to leave an SME major was always the culmination of a dialogue with self and others over time, in which students were drawn back and forth between the options that seemed open to them. Typically, the process began with poor experiences in SME classes in their first year and, for some, the discovery of under-preparation. It was deepened by a series of academic crises and disappointments that provoked anger towards a particular faculty, advisors or teaching assistants. Students began to experience self-doubt and lowered confidence in their ability to do science. They became disillusioned with science and the science-based careers to which they had aspired, and questioned whether getting the degree would be worth the effort and distress involved. Only then did they begin to consider a switch to those non-SME classes where they had experienced better teaching and/or more satisfaction with their academic work. Potential switchers discussed these experiences with others, and, even at a late stage, some who came very close to switching decided to stay. The process of moving back and forth between thoughts of leaving and staying lasted from a few months to over two years. (Seymour & Hewitt, 1997, p. 393)

Based on their findings, Seymour and Hewitt (1997) state that the problems which arise from the structure of the educational experience and the culture of the discipline (as reflected in the attitudes and practices of STM faculty) make a much greater contribution to STM attrition than the individual inadequacies of students or the appeal of other majors.

All the students in the study had a mathematics SAT (Scholastic Assessment Test) score of 650 or higher, in order to include only students whom could be expected to be able to handle the course work (1997, p. 25). SAT is a standardised test for college admission that *inter alia* tests the mathematical skills of the future students. The test is widely used in the US. Furthermore, even though some switchers reported that they felt inadequately prepared from high school, this was also the case for a similar

proportion of non-switchers, and it was ranked quite low among the different factors reported to influence switching (ibid., p. 36). In effect, the institutions lose at least two groups of students whom the STM faculty might actually prefer to retain, namely the 'more pulled than pushed' and 'the more pushed than pulled'.

The first group of students includes very able, often multi-talented, students who have a strong interest in science and mathematics and who would have stayed had the teaching been more stimulating and the curricula more imaginative. The second group of students includes those who felt they had the ability to complete an STM degree, were adequately prepared, and entered their STM major largely on the basis of interest. They became discouraged by poor teaching and aspects of the so-called 'weed-out process' (an idea and tradition that students should be sorted in order to keep the better and dismiss the less-able students, for instance through high pace in the teaching; we discuss this further below). Although these students would prefer to stay in the sciences, they move into majors which they regard as a poor compromise. Here many women and students of colour are found. They felt their choice of an STM major had been appropriate and that they could have completed it, given some support and a less 'cut-throat atmosphere' (ibid., p. 393).

In other words there seems to be an agreement between Seymour and Hewitt's study of STM students and the more general research on retention and non-completion of students in focusing less on the students' prior knowledge or preparedness, and more on the teaching and learning experiences the students are presented with once they have entered the programmes.

This point, as well the fact that switchers and non-switchers to a large extent experience the same kinds of problem, result in Seymour and Hewitt using the metaphor of an 'iceberg' to represent the experiences of the students: 'Those who switch represent only the tip of a much larger problem' (ibid., p. 31). The differences between the students are not that one group is more or less willing to face the 'hardness' of the study, or are more or less talented or well prepared; as mentioned above all students were high achievers in the SAT tests. The difference between the group of students who stay and those who leave is much more complex.

What Seymour and Hewitt point out is that the metaphor of 'weeding out' implies an incorrect notion of selecting the able and getting rid of those not fit for studying STM. What is more, the idea of 'weeding out', which they claim is a long-established tradition, and holds 'a semi-legitimate, legendary status' (ibid., p. 122) is detrimental for the STM studies for at least three reasons. The first is, as just mentioned, that it does not select the talented and exclude the non-talented. There are no significant differences in the level of performance between those who are excluded through the weeding out process, and those who are not. Secondly, students experienced the system as counter productive, because it eventually caused students to focus on memorisation rather than comprehension. Thirdly, it promotes a student behaviour that, *inter alia*, discourages any collaboration between students that could have improved the learning experiences (ibid., p. 130f).

It seems that the STM programmes lose students with interest and abilities within the field because the pedagogical approach and the study environment are unattractive, and that the learning experiences of the students lead them to lose interest in science. These poor learning experiences to some extent are related to the traditions and ethos of the disciplines, as is the case with the 'weeding out', but also the generally low priority that students experience is given to teaching by science faculty: 'They strongly believed that the source of these problems [poor teaching] was that the

S.M.E. faculty do not like to teach, do not value teaching as a professional activity, and lack, therefore, any incentive to learn to teach effectively' (ibid., p. 146).

For the female science students, the poor learning experiences were also related to the notions about women and science. Female science students had experienced male faculty implying that women were not welcome in their classes, and male peers holding the view that high-achieving female students were considered unattractive. If the female students proved to be skilled in science they would be considered un-feminine and unattractive; if they did not, they would confirm the prejudice that women and science are incompatible. As Seymour and Hewitt put it, the women cannot win without losing (ibid., p. 262).

Leaving STM higher education courses: general research

There have been a large number of studies within the field of drop out/opt out since the publication of Seymour and Hewitt (1997). In her 2002 article Seymour paraphrases Einstein, and states that there is a growing recognition that: 'You cannot resolve a problem in the conditions that created it' (Seymour, 2002, p. 81). However, many of the studies still focus on retention as a matter of increasing students' skills before or during the first year of study and they aim at identifying factors associated with students' academic success (Ariadurai & Manohanthan, 2008; Bonous-Hammarth, 2000; Burnett, 2001; Dyer, Breja, & Wittler, 2002; Mills, Heyworth, Rosenwax, Carr, & Rosenberg, 2009; Yan, 2002). Only a few studies have focused on changing university cultures, including teaching practice. Yet, the field of research that addresses the issue of identity seems to have promising perspectives and as we will outline in the following, several studies have illuminated the significance of addressing the university culture when discussing retention.

Trying to understand the problem

Part of the literature focuses on understanding the problem of students not completing STM-education. Some studies are very context specific dealing with one specific programme and taking as the point of departure the students' experiences at this particular programme. This is the case with the study of Fozdar, Kumar, and Kannan (2006) that found nine factors of significance for students leaving the BSc programme offered by Indira Gandhi National Open University, India. A number of these factors are related to the physical distance between students' home and the university. This causes problems, both in attending classes and in getting to interact with other students. Other factors relate to the support system as being absent or insufficient. One factor related to difficulties with the examination paper.

Another study of this type is Sorensen (2000) who focused on student retention in relation to changes in curriculum policies, in a study of students identifying themselves as life-science majors or undeclared pre-meds (that is, students aiming at a medical career without having selected a field) at University of Austin, Texas. The study shows that no demographic data including gender and ethnicity were found to be predictive for students' success. On the contrary the study finds that the structure of curriculum and the sequence of courses were an important predictor. A similar conclusion is reached in a UK context by Porkony and Porkony at a first year undergraduate introductory statistics module. The study aims at identifying

factors that explain the variability of student performance, but the conclusion is that there are no simple predictors of students' success or failure (Porkony & Porkony, 2005). Other research reaches other conclusions. Research carried out at The University of Western Australia identifies factors to be associated with successful academic performance studying students in health science. Mills et al. (2009) identify a range of influential factors, but they find that the factor of most influence on first year students' academic success was matriculation score and the most influential factor on students' retention was first year marks.

Other studies change the point of view from focusing on students' skills and success to focusing on the institutional level. Daempfle suggests that student success and difficulties are related to incongruity between secondary school and post secondary faculty assumptions about what kind of scientific knowledge is important for first year biology students to be successful at college in North Eastern US (Daempfle, 2002). The conclusion shows that secondary faculty viewed as important that students could find the right answer to a question, to learn to look for important things in a book and that students could be successful without being analytical. The post secondary faculty on the contrary expected students to have a critical approach to science and realize that solutions are not always black and white. The study suggests a gap between secondary and post secondary faculty and that communication between faculties could be helped by paying attention to these epistemological differences and make students' transition to college easier.

Fenwick-Sehl, Fioroni, and Lovric (2009) discuss different efforts initiated by mathematical departments in Canada to increase the number of graduating mathematical students. The authors argue that the way mathematics and science are conceived by potential students and their parents discourages students from applying for these study programmes. But they also point out that some of the ways they found mathematics to be promoted were misleading (e.g. the images of careers in mathematics), and that the emergence of new fields of application in mathematics, such as biological sciences, pose a challenge to the discipline's self-conception. This is not least the case regarding 'applied mathematics', but in order to attract students precisely this should be addressed by the members of the discipline (Fenwick-Sehl et al., 2009).

Studies reporting on initiatives to increase students' skills

A large number of studies are based on the assumption that retention is linked to students' skills and especially their mathematical skills. These studies range from reports on diagnostic testing of students e.g. calculus competencies and development of summer schools to address this issue (Turner, 2008), redesigning the calculus sequence (Keynes, Olson, Shaw, & Wicklin, 1999), using specific tools like Python programming languages in introductory computer programming (Nikula, Sajaniemi, Tedre, & Wray, 2007) to more intensive programmes that combine content lectures, pre-examinations, learning styles assessments and informal sessions to provide the students with a preview of the requirements of biology and the pace of college (Wischusen & Wischusen, 2007) and finally developing a university-wide strategy for mathematics support (Croft, Harrison, & Robinson, 2009).

Another perspective in this group of studies is targeted at women, ethnic minority students and financially impoverished students and their lack of skills and

possibilities, e.g. the effect of financial aid. Research shows that financial aid actually improved minority groups' persistence and graduation rate but these students took a longer time graduating than non-STM minority students receiving similar financial support (Fenske, Porter, & DuBrock, 2000). St. John, Shouping, Simmons, Carter, and Weber (2004) examined the influence of college major field on persistence for white and African American students finding no differences for science and mathematics, but with African American sophomore students in engineering and computer sciences as well as in health and in business being more likely to persist. Other studies have used quantitative analysis to determine factors from high school physics preparation and affective factors to predict female and male performance in introductory university physics (Hazari, Tai, & Sadler, 2007) or the effect of creating a partial single gender environment in a mixed gender classroom during a third-year university software engineering course, where female students experienced improved learning opportunities (Cox & Fisher, 2008).

Studies reporting on other initiatives

Several studies report on projects aiming to ease students' integration into higher education, often focusing on introductory courses (Soh, Ashok, & Nugent, 2007) or the first-year at university (Estaville, Brown, & Caldwell, 2006; Jamelske, 2009). Fishman and Decandia (2006) report on a multi-faceted approach involving several components, e.g. an extensive transition and orientation programme offered prior to the first semester intended to prepare students to meet the challenges of college life (social activities to attain a sense of belonging and connectedness to the college programme and community; a series of success and learning skills workshops to provide students with specific strategies for academic and personal success; mock lectures to allow students to experience the classroom environment and obtain valuable classroom strategies from a learning strategist). Other elements included an online portal to allow students to develop their academic strategies and study skills, explore career options and enhance their communication and relationship skills, an early warning system to identify and assist students at risk, ongoing workshops, social activities and electronic communication to promote a sense of connection and support.

A small number of studies have focused on the role of the teacher. Ronco and Cahill (2004) discuss the effect of instructor type on student retention, achievement and satisfaction, and uncovered little evidence that instructor type has a widespread impact on student outcomes. A similar study describes a course for professional preparation of mathematics graduate students to prepare them to become effective teaching assistants (Harris, Froman, & Surles, 2009). They find that graduate students who took the course were viewed by their students as much more likely to welcome and encourage questions and comments, and as more likely to be available for out-of-class consultation and to present information beyond the text. The authors find that taking the course had increased the graduate students' confidence and comfort with related impact on their teaching practice.

The majority of the studies on retention of STM students conducted since Seymour and Hewitt published their work still have a strong emphasis on how to equip the students to meet the requirements of the programmes. The studies address a variety of issues including teaching methods and different compensatory measures (both financial and concerning disciplinary knowledge), some of them following the

points from the 1997 study of Seymour and Hewitt. Very few of the studies seem to address the point that switchers and non-switchers are very much alike.

Leaving the STM higher education courses: research on identity

The research presented in this section represents a different approach to the understanding of what may cause some students to leave their STM programme before graduation. The approach puts 'identity' at the heart of the question.

Identity is a concept which, though originally from the field of psychology, has spread to a range of other disciplines, e.g. anthropology, history, sociology, linguistics and feminist theories (Holland, Lachicotte Jr., Skinner, & Cain, 1998, fourth printing 2003; Wetherell, 2009). Research focusing on identities is rare in the field of science education, but in recent years it has become a subfield in the study of students staying at or leaving STM programmes, as well as being applied to the study of recruitment (e.g. Schreiner, 2006; Archer et al., 2010; Hsu & Roth, 2010).

Identity has been conceptualised from a number of different theoretical perspectives. These positions constitute a continuum from the idea of the individual as stable and coherent to the notion of identity as being multiple, flexible and continually renegotiated. From the first perspective identity is perceived as an individual's psychological property which is considered to be separated from the social world. This position is mostly adopted by older theoretical positions in psychology, as the work by for instance Freud and Erikson; however, it is also a notion that can be traced in a generally Western understanding of identity (Holland et al., 2003). The second conception of identity is inspired by philosophers such as Foucault, Deleuze, and Lyotard (Stentoft & Valero, 2009; Wetherell, 2009) and adapted to psychology by post-structural and social-constructionist theories (Gergen, 1991; Butler, 1990; Davies, 2000).

Presently, most theories of identity position themselves somewhere along the continuum, understanding identity as being relationally formed and socially produced (Holland et al., 2003, p. 28). According to some identity theories, identity and actions are fully interwoven and therefore conceived as different facets of the same productive flow of social life. Other theories regard identity and action as separate entities, thereby implying that there is a distinction (or boundary) between the social and the psychological (Wetherell, 2009, p. 15). The idea of such a boundary allows for a historical dimension – a kind of historicity in the concept of the self (Wetherell, 2009). Briefly, the construction of identity is still considered as an on-going process, but in a way where the past experiences of the individual is involved in the practice, that is in the way the individual interprets, negotiates and acts in the situations.

Distinguishing between the psychological and the social should, however, not imply that the individual is positioned outside the social or the culture. We understand identity as always being embedded in culture. When entering university, newcomers have to figure out the social and cultural setting which they enter, and relate that to their identity. Accordingly, Hasse (2002), in her study of first-year physics students, suggests an understanding of culture as a learning process, and as related to a social practice. In a similar manner, we understand identity as a social practice, and we are interested in the process of identity-work young people go through when entering a new study programme. In that sense, we focus on how young people are trying to make sense in organising and structuring their experienced life into coherence and into narratives about themselves and their surroundings (Crossley, 2010; Sarbin, 1986; Taylor, 2009). At the same time we are interested in the way people's past experiences

influence their actions and ways of positioning themselves. Both these perspectives, that is, identity as an ongoing process, and identity as a product of past experiences, are found in narrative psychology:

> The narrative psychological approach comprises a useful tool which enables us to recapture the way in which selves and identities are grounded in "cultural" forms of language and sense-making whilst still maintaining a sense of the "internal", "coherent" and "personal" nature of self-experience. (Crossley, 2000, p. 533)

This coherent self is not to be confused with an inner, stable, unconscious self. Rather, is has to be understood as if the stories being told by a subject also enable and limit the possibilities for which stories are to be told in the future (Taylor, 2009). In this paper, we espouse a notion of identity similar to the one formulated by Holland et al.:

> We are interested in identities, the imaginings of self on worlds of action, as social products; indeed, we begin with the premise that identities are lived in and through activity and must be conceptualized as they develop in social practice. But we are also interested in identities as psychohistorical formations that develop over a person's lifetime, populating intimate terrain and motivation social life. (Holland et al., 2003, p. 5)

We posit that selves and identities are grounded in 'cultural' forms of language and that the way young people make sense is grounded in culturally recognised scripts in relation to social practices (Crossley, 2010). At the same time, identity has, to some extent, continuity, inertia and even stability. It is – so to speak – changeable without being volatile. We therefore see identity as an ongoing process embedded in cultural and social practices, but at the same time we focus on how identities develop over time as psychohistorical formations.

Based on the research findings we presented in the section on general research on retention, it appears meaningful to apply an approach to the understanding of drop out/opt out among young people from STM higher education programmes that is informed by a narrative psychological conception of identity. If entering a study programme is regarded as a process of socialisation, then identity is a core concept for understanding how students relate to the study experience and to the culture and environment they encounter. Since the integration into the culture of the discipline *inter alia* is brought about through the teaching and learning activities and the feedback from the teachers (Hasse, 2002), then the relation between these elements in the courses and the identities of the students is of interest. This is in line with the emphasis that both Seymour and Hewitt (1997) and Harvey et al. (2006) put on the students' study experiences – not least during the first year.

The importance of the identity issue manifests itself in the following quote from a cultural-historical and socio-cultural framework:

> As science educators we seem aligned with the view that those who study science education can learn and build identities that reflect an affiliation with science. It is also possible that, through the study of science, participants, might resist affiliation and reject what it stands for. Perhaps then it is about their choice. Throughout science education individuals get to choose whether to affiliate with science or not. (Tobin & Roth, 2007, p. 340)

In the quote from Tobin and Roth it may appear as if identity is something students actively and rationally change, reject, transform and choose. However, following the authors' socio-cultural and cultural-historical approach, this is not the case. Rather

than being rational in the sense of being the conclusion of a conscious process of the mind, it is rational in the sense that it is the meaningful action or practice that is available to the student, being embedded in a culture and bringing with him or her a history and experience of interpretations and practices.

In this section, we give special attention to studies carried out in the field of drop out/opt out that both implicitly and explicitly apply the perspective of identity to understanding students' leaving STM programmes. These studies focus on the effects of a study programme on his or her identity, and the impact identity has on the student's adaptation to the cultural settings of the programme.

Previous research on identity and student persistence in STM has to a large extent applied quantitative methods (see for instance White, Altschuld, & Lee, 2006; Schreuders, Mannon, & Rutherford, 2009; Wasburn & Miller, 2004–2005; Xu, 2008). In a review of studies on women in computer-related majors Singh, Allen, Scheckler, and Darlington (2007) find that the quantitative studies are primarily based on descriptive analyses, individualised measures, and implicit theoretical frameworks.

In their discussion, Singh et al. (2007) critique the treatment of 'women' as a homogenous group in many studies. They argue that in studies where 'female students' are claimed to be the research object, the differences within the group of female students are concealed, for instance differences across study programmes, social backgrounds, ethnicity etc. and they point to feminist theories as a place to look for approaches:

> To begin, the conceptualization of women must be elaborated from a unitary notion of woman to include how gender intersects with race, sexual orientation, nationality, and other ways in which lives are socially constructed and constrained. (Singh et al., 2007, p. 517)

From a feminist perspective the issue of identity is always entangled in a set of power relations where certain gendered identities are included while others are excluded. Likewise, Hasse (2002, p. 73) argues that labelling groups with a mutual identity tag (like 'women' or 'physics students') conceals differences between the individuals, and eventually how they become more or less included in the culture. However, frequently the data available do not allow quantitative studies to take full account of these differences and allow them only to draw up a relatively crude image of the situation.

The qualitative methods used in the research to understand identity issues vary from life history interviews with a small sample of students (Wood, 2002), focusing on already ongoing initiatives (Davis, 2001) to methods involving a range of qualitative methods (Carlone & Johnson, 2007). This research is primarily from a US context and mainly related to minority representation problems, in particular the lack of women or non-white students (or both) in STM programmes.

Identity, in-between subject and culture

In one of the examples of European research addressing identity within STM education, Stentoft and Valero state that:

> The notion of identity represents a way to move beyond the existing debate on whether mathematics learning is in essence individual or social. It can be seen as a notion which may assist researchers providing the missing link for grasping the dialectic relationship between the individual and the social dimensions of learning (Sfard and Prusak, 2005

> p. 15); and therefore it has been taken as a fruitful concept for providing more sophisticated interpretations of processes of mathematics education practices (Stentoft & Valero, 2009, p. 56)

Following Stentoft and Valero, applying a socio-cultural post-structural perspective on identities is a way of building a bridge between looking at students leaving university as being either an individual or an institutional problem. Also, it is a move away from a dichotomised perception of the problem to a more dynamic understanding where identity is considered a fragile and ongoing process embedded in the institutional discourses and practices, closely related to the students' actions and participation. In this perspective identity is a process rather than a stable entity, where the individual produces culture at the same time as being produced by culture. This notion of identity is not widespread in research in science education, but there are some examples of literature applying this approach.

Based on a study of women of colour working on constructing a science identity, Carlone and Johnson (2007) discuss identity as something closely connected to recognition, using a socio-cultural framework:

> Identity is not just something an individual feels; it is not even what an individual does, although both feelings and actions are components of identity. A science identity is accessible when, as a result of an individual's competence and performance, she is recognized by meaningful others, people whose acceptance of her matters to her, as a science person. (Carlone & Johnson, 2007, p. 1192)

This strongly connects identity to cultural settings and to other individuals, meaning that the students are not free to construct an identity on their own. They are dependent on recognition from others, and to obtain this they have to make themselves recognisable as legitimate 'science people'. This recognition has to be obtained in a context that is derived from socio-historical discourses of science and what science is, and from historical meanings and societal images of being a woman in science.

Carlone and Johnson (2007) state that the practices of school science often emphasise science as a finished body of knowledge. This, at the same time, promotes students with very narrow science identities and excludes a broad range of students from constructing a science-identity which is recognisable in the field of science:

> Broadening students' participation in science requires close attention to the kinds of people we ask students to become as they participate in science activities, and to the ways girls, women, and students of colour embrace and resist these promoted science identities. (Carlone & Johnson, 2007, p. 1189f)

It follows from this that recognition tends to reproduce the existing culture, which in many STM programmes means the hegemony of a culture of whites and males. Not being a white male then means that one has to be able to negotiate and redefine culture and identity in order to be recognised (Carlone & Johnson, 2007), or that non-whites and non-males have to comply even more with other aspects of what counts as 'doing science', for instance in choice of specialism or in how strictly one confines the science practice to traditional methods or themes within the discipline (cf. Søndergaard (1996) for a similar point within the social sciences).

In reviewing other research about women of colour in engineering, Tate and Linn (2005) outline the following as influencing their persistence:

- Women persist in STM fields when they feel welcome, have access to role models and mentors, and form bonds with other women in STM.
- Women persist when they encounter supportive interactions with technology.
- Women are more likely to persist in the computer science field when they can reject the fields' dominant culture.
- Self-confidence is a major factor in the persistence of underrepresented groups.
- Women and ethnic minority students pursuing STM majors deal with differences in ethnic cultural values and socialization, stereotypes, isolation, perceptions of racism and inadequate program support (2005, p. 483f).

In their study, Tate and Linn (2005) use a multiple identities framework that is grounded in situated cognition theory, with reference to Jean Lave and Etienne Wenger, and therefore they pay particular attention to the social relations and communities the students engage in. Rather than talking about 'student identity', Tate and Linn distinguish between three identities: social identity (the view of self in society or through society's eyes), academic identity (activities and success) and intellectual identity (desire to be an engineer and insight in the engineering field). They conclude that:

> The multiple identities framework also reveals the intersections of the identities. Students' social identity may affect their academic identity. For example, a student who feels uncomfortable in an engineering environment may experience difficulty in forming study groups helpful to their academic performance. (Tate & Linn, 2005, p. 491)

The work of Tate and Linn draws attention to the diverse contexts and communities students engage in, and consequently suggests that studies of students' experiences at university that only address one of these identities may provide a misleading image of the students' situation. Furthermore, their work emphasises how these multiple identities influence each other.

Other research taking up a more pronounced post-structuralist perspective emphasises that identity is so closely woven into the social and the cultural that they are inseparable. Hughes (2001), in a study of a group of students consisting of both males and females and of students of different ethnicity in a UK city school and post-16 city college, focuses on how identity is connected to recognition and to which positions are available in the construction of a science identity. She points out that different curricula and teaching methods make different potential identities available to students with gender or ethnicity different from that of the majority of students in STM. Consequently, she cautions against simply linking particular genders to particular sciences. Instead, she concludes that 'socially relevant and more constructivist science can generate a wide range of scientist subjectivities, increase the possibilities for scientist identities and thus open the way towards a more inclusive science curriculum' (Hughes, 2001, p. 288).

Malone and Barabino (2009) in their study also touch on the different positions made available to students, and the struggle of minority students to integrate a scientist identity with how they are recognised (and through that: positioned) by others. They consider this process of recognition to be carried out in every utterance and interaction, and for minority students it meant having to deal with being seen as 'the one' – that is, different from the others:

> Research and our own study suggest that laboratory and educational interactions can lead to and/or provide the conditions for forming an identity as researcher, professor, and

> scientist; yet many times we find that underrepresented minorities face identity impasses rather than opportunities to deepen and integrate identities within a university setting. These difficulties in identity integration are one facet of being the "only one," meaning that a person is "one" rather than brought into a community of practice where one is automatically part of "we". (Malone & Barabino, 2009, p. 505)

Malone and Barabino (2009) conclude that being included in STM is difficult if approaching the culture with a background other than white and male. Not being included in the academic community impedes integration at university and the construction of a science identity (Malone & Barabino, 2009).

As it is, applying identity as a theoretical perspective in understanding students' experiences and student persistence is primarily found in studies focusing on minority students, which in an STM context includes both ethnic minority students and women. However, if attending university, as we argued earlier in the paper, is a process of socialisation (cf. Tinto, 1998; Becher, 1989; Becher & Trowler, 2001), then it seems relevant to address the identity issue for majority students as well in trying to comprehend the question of persistence or opting out. This seems even more relevant considering the finding of Seymour and Hewitt (1997) mentioned earlier that the most common reasons causing students to switch programmes were rooted in experiences shared by both switchers and non-switchers. However, that these experiences were shared does not mean that they were identical. Both in relation to women and to students of an ethnic minority Seymour and Hewitt note that there are particular difficulties for students in those groups. In relation to gender:

> When women first enter S.M.E. classes, they encounter two kinds of experiences, both of which are new and uncomfortable. They share one of these – the weed-out system – with their male peers. They do not, however, assign the same meaning to the weed-out experience as the men and, therefore, do not respond to it in the same ways. […] The other new kind of experience for women arises as a consequence of entering a social system which has been traditionally all-male. This creates problems for women which men do not have to face. (Seymour & Hewitt, 1997, p. 255)

According to Seymour and Hewitt (1997), both women and ethnic minority students experience particular difficulties due to their socialisation being different than the dominant white, male culture, and due to their being positioned and recognised in particular ways owing to their gender or ethnic background. This point is in accordance with the studies addressing identity issues, e.g. by Hughes (2001) and Malone and Barabino (2009). It further suggests the importance, not of individual traits or characteristics, but the intersection of different characteristics and how they are recognised, interpreted and acted upon by both the individual and by others in the academic culture and community.

Curriculum culture

Accepting culture as an important issue for understanding retention not only refers to the study environment, but also to the culture in the curriculum and the discipline. As mentioned previously, Hughes (2009) discusses how science is frequently considered rigid, and thus a solution that has been proposed to favour girls would be a more 'feminine' science curriculum, that is, a contextual, cooperative and student-centred orientation of the curriculum. However, Hughes emphasises that this is a strong generalisation that does not reflect that fact that that not all men are

attracted by the 'masculine' sciences, and that some women favour the 'masculine' domains of science. Ascribing a particular gendered quality to particular areas or approaches in science also runs the risk of essentialising specific aspects of science, that rather are subject to change and negotiation. Likewise, it tends to over-generalise the preferences of women and men.

On the other hand, even if gender and the gendering of disciplines are not regarded as inherent properties of the discipline or the students and faculty involved in it, but rather as dominant discourses and storylines through which the construction of identity evolves (Walker, 2001), then ascribing for instance the adjective 'masculine' to the language or culture of a discipline still influences the process of negotiating identity that male and female students have to engage in. Drawing on interviews with six male and nine female engineers at a Scottish university, Walker (2001) argues that even if students tend to consider gender as something that is not an issue, gender questions still permeate a substantial part of the stories told by the students. However, students' rejection of gender as an issue of concern obscures the power issues related to gender, and makes it impossible for the students to address these experiences, except through ambivalent or inconsistent narratives. A noteworthy point made by Walker is that this not only limits the possibilities for the female students, but also for young men who wish to relate to alternative constructions of masculinity. Likewise, Hasse (2002) concludes that femininity is considered at odds with being a physicist. The female students therefore have to play down markers of femininity in order to reduce the risk of being dismissed as less capable based on their gender alone. Similarly, Seymour and Hewitt (1997) reported that women students experienced having the legitimacy of their studying science being questioned because of their gender.

Hughes's (2001) research is focused on gendered constructions of identities within the dominant discourses and practises of science curriculum and draws upon qualitative studies in the UK consisting of in-depth classroom observations and semi-structured interviews with 60 students. Material from staffroom observations and interviews with teachers is not included in this particular article by Hughes. She concludes that 'scientific knowledge in the dominant curriculum discourse is presented to students as detached, incontestable and inaccessible' and that physics is being 'held up as the ideal model for positivist science'. Further, she comments:

> Where these dominant curriculum discourses are very pervasive in physical sciences, available scientist positions subjectivities are likely to be are limited in a manner that is consistent with statistical evidence that physical science is the preserve of high-fliers and/or middle-class males. However, there are assured scientist subjectivities available for some female students that depend on possible interactions between ethnicity, marginality, educational background/achievement as well as gender, a point that has been underemphasised in many previous studies. […] constructivist, student-led investigations, observed here in biology, offer opportunities for reconfiguration of dominant discourses. Here new scientist subjectivities that do not depend on exceptional achievement and/or adherence to gendered binaries emerge. If competing discourses were also more available in physical sciences, then a similar expansion of available student scientist positions might also develop for females and males alike. A reduction in rigid science/non-science specialism could also support more hybrid identities. (Hughes, 2009, p. 287f)

Internal culture of the subject taught is the point of departure in students' construction of identity as they work to belong in the culture of science (Hughes, 2009).

Academia as working culture

Research focusing on gender differences in academia underlines the importance of support from more experienced students mentoring the newcomers, but also from women who already have established careers and are invited to campus to share strategies and serve as role models for freshmen (Wasburn & Miller, 2004–2005).

Ferreira (2003) studies gender differences among students in two graduate science departments of chemistry and biology at a large US Mid-West research university. She points out that if the goal is to attract more girls to science in general and to chemistry in particular, it calls for a change in the workplace culture where all permanent staff were men, and the culture was based on traditional male cultural norms. Changes in this department would require that more women were hired at the department to serve as role models and mentors. However, findings from the analysis of the other department included in Ferreira's study suggested that hiring more women is not enough; a change in the workplace structure is also needed. This biology department implemented a number of changes to help staff to balance working life with family, but in spite of this the students still perceived the possibility of combining family and academic career as too difficult and the effort needed to be too excessive. The students experienced women hired at university as being stressed and the position to be unattractive. Indeed, the female staff almost served as *negative* role models. In this case, academia is excluding students who wish to combine an academic career with something else (for instance a family life). A more fundamental change in the working culture in academia is needed to attract more female students, but also alternative options for those students who might consider a career in science other than research in academia (Ferreira, 2003).

In her research, Davis (2001) followed a group of women working in a research institution in the Western US. The women met once a week in a self-established network to discuss their everyday environment and to share experiences. These women considered themselves as being peripheral and subversive. In joining the network, the women became aware of their personal experiences as cultural products rather than a result of issues relating to themselves as individuals. The network turned out to be supportive, providing the participants with a critical perspective on the culture of science, constructing a new discourse inclusive of diverse voices, developing a critical view of the science community and legitimising their own positions. Davis concludes that the women in her research did not have access to powerful networks, and the science community must take primary responsibility for constructing inclusive, equitable, and participatory networks, structures, policies, and practices within the community (Davis, 2001). This research demonstrates the importance of changing the perspective from understanding something as an individual and isolated experience to realising it as a structural problem. Making students who consider leaving their study change their perspective on what they conceive as individual problems in order to make them reflect on them as related to the structure as well, could be a useful tool in including not only the minority of girls in science, but for the retention of students in general.

The research focusing on identity draws upon a range of perspectives. Still, it shares an emphasis on the importance of the interaction between the individual student and the culture of the discipline. Secondly, it highlights the importance of being recognised as a legitimate member of the group of science students or 'science people'. Thirdly, it draws attention to the point that some positions are available to some

students rather than to others. Overall, there is an emphasis on the socio-cultural aspects of studying, and the analysis of the under-representation of particular groups of students.

The research focusing on culture and identity gives more attention to cultural elements like discourse, role models, and values. Fewer studies devote their attention to the teaching and learning activities and what, following Bernstein (2000), could be called the pedagogical discourse. This would include studying the curriculum in relation to what content is included and what is excluded, to what extent the different elements of the study are integrated or separated from each other, and how the control over the pacing and sequence of the teaching is distributed (Bernstein, 2000). The limited interest of the identity-focused approach on the teaching and learning activities means that this research is more helpful in analysing the importance of what is surrounding the teaching, than in understanding the impact of the teaching methods the students meet.

What could be done about students leaving?

Our review has shown that there are numerous factors influencing student completion, and that these interrelate and influence each other. Some factors relate to the situation prior to the students entering the university (primarily the students' social background and the programme choices made by the students). Other factors relate to issues outside of the university (for instance housing, finance or personal issues – not least for mature students). Finally there are factors within the study programme itself. The theoretical models (e.g. that of Tinto), and much of the empirical research, place the students' experiences with the teaching and learning environment at the study programme as the pivotal point.

It follows that there is no one instrument or change that can solve all the problems. Yorke and Longden (2004) conclude their book by discussing what the institutions, the students and the higher education system could do, though most of the authors' propositions are aimed at the institutions. Some of those have to do with the information provided to the students that should address for instance course content, methods of assessment, expected time-commitment, costs and more. They strongly recommend that students visit the institution. The student experience is addressed by a number of issues. Some relate to the welcoming and induction process, which should include information about the study (but they also warn of information overload in the introduction). Further, it should aim at making the students feel welcome, and aware that the institution and the teachers are concerned about the learning experiences of the students. The whole of the first year could be regarded as an extended induction process, they claim, while at the same time they note the importance of the very first lecture or teaching activity the students are involved in, and the importance of the signals this lecture sends. There are two issues here. Firstly, it expands the induction process from a few days or a couple of weeks to the entire first year, indicating that the induction process should more or less permeate all the teaching and learning activities during the first year. Secondly, it emphasises the importance of the initial meeting with the faculty, teaching, peers and culture, and that the institutions therefore should be careful with the first activities the students are exposed to.

Other suggestions by Yorke and Longden relate to the teaching, emphasising both the general learning environment that should be supportive and have the student as a

central focus (and should encourage staff to give more attention to teaching), but also the modes of assessment used, not least the importance of formative assessment, and an early and extensive use of this. Another suggestion is to have a 'disproportionate allocation' of teaching resources, so that first-year teaching is allocated more teaching resources than the advanced courses to give room for smaller teaching groups and interaction with staff.

Yorke and Longden's focus on the student experience and student success put emphasis on the interaction between student and study programme, and it places the choice of programme, not least the teaching and learning experience, at the heart of the matter.

Seymour (2002) provides a detailed review of the processes of change in SMT undergraduate education in the US. She shows how views have changed from statements of a 'pipeline problem' linked to a question of students' abilities, to recognising that the pattern of losses might be (unwittingly) engineered rather than reflecting a 'natural' wastage. What was initially seen as a matter of supporting individual students (precollege bridging programmes, personal and academic support, and enrichment programmes for under-represented groups of students) is gradually recognised as a challenge not only for targeted groups, but a challenge to improve the quality of the undergraduate learning experience for all students. It is in this context that Seymour, as mentioned earlier, paraphrases Einstein, and states that there is a growing recognition that: 'You cannot resolve a problem in the conditions that created it' (Seymour, 2002, p. 81).

In the last part of her paper, Seymour (2002) provides an overview of current reform activity and examples of initiatives taken or underway to address the issues of students leaving STM educational programmes. She further links these initiatives to what she calls theories of change. These theories are shortly outlined in the following.

One view is termed: *bottom-up and top-down theories of change*, and reflects the theory that reform across institutions or systems can be transmitted by the spread of grass-roots action between individuals, campus groups, and networks. It argues that change can be built from small local beginnings, first by provoking and maintaining conversations that lead to local collaboration; then by making connections with collaborators on the same or other campuses. Thus, it is claimed that good ideas, supported by convincing evidence of efficacy, will spread 'naturally' – that, on learning about the success of particular initiatives, others will become convinced enough to try them.

This set of theories has however, as discussed by Seymour (2002), not been supported by evidence, and it has not been proven that networks of such collaborations can build into a 'critical mass' in favour of reform. Within this position it is today recognised that: 'System change within institutions requires unequivocal, high-level commitment to promote and reward classroom effectiveness and educational scholarship' (Seymour, 2002, p. 93). Individual efforts of reform-oriented, proactive faculty are necessary, but not sufficient, and require an institutional cultural transformation.

Another view is termed *the blueprint model*: good intentions have to be channelled into actions that are already known to be effective. Time, effort, and resources should not be wasted on strategies that have not worked well in other comparable settings. This approach therefore calls for workshops or other means of facilitating professional development, for instance access to summaries of pedagogical and assessment techniques, the theoretical and research base for these and evidence for their efficacy – including what did *not* work. This view or theory of change is related

to yet another view, namely that *evidence is a necessary (if not sufficient) condition for reform*.

Both these theories of change face difficulties *vis-à-vis* the culture of the SMT faculties and to some extent of the students too; an issue touched upon in the theory labelled *departmental values are key to educational improvements*. Finding the means to leverage relevant shifts in departmental values and practices is the critical factor in determining whether the efforts of faculty – as individuals and groups – and of their institutions, will be able to improve the quality of STM education, or achieve the wider goal of science-for-all.

What is more, there is a history of SMT faculty not valuing teaching which limits teachers' inclinations to enter into pedagogical experiments or investigate new ways of teaching (Seymour & Hewitt, 1997). As DeHaan (2005) points out, this means that scientists trained to demand evidence for their actions when it comes to teaching neglect the evidence that exists, both due to ignorance of the evidence available, but also because of scepticism toward the methodologies underlying the evidence.

Another important issue is resistance from students who have learned how to get good grades through passive learning methods and who find it harder to achieve the same grade levels through a pedagogy that often demands more of them (Seymour, 2002). Furthermore, the fundamental difficulties in providing evidence for specific pedagogical changes notwithstanding, Seymour (referring to Paul Mazur's book, *Peer Instruction* (1997)) asks why new initiatives need to present evidence that they work, when there is a lack of evidence that the established teaching formats are effective.

The cultural aspect is also present in the view which Seymour (2002) labels: *alignment is required at all levels for effective system change*. In order to make the curriculum more meaningful to students, there should be an alignment between learning goals and the teaching and assessment strategies (cf. Biggs & Tang, 2007). However, there should be alignment on a broader level too: attempts to alter single elements in a complex social system will not be effective; each element must be aligned with the others for system changes to prevail.

Hence, it becomes clear that the organisational issue is bound to take the cultural aspects into consideration when suggesting initiatives and taking actions to change the teaching and learning environment in SMT programmes. The two last views, or theories for change, that Seymour presents relate to this point. The first, *rebalancing the departmental rewards system to reflect respect for teaching and educational scholarship*, argues that the fastest and most enduring way to promote a renewed emphasis on teaching in the service of learning in higher education is to restructure the faculty rewards system. Presently, as Seymour reports from her study, staff members are not rewarded for involving themselves in the development of the teaching at the department. She reports examples of staff having been denied tenure because they were considered as investing more experimenting and productivity into teaching than into research. Likewise, tenured staff state that they advise untenured staff not to involve themselves too much in educational scholarship or classroom experiments until they have 'survived' the system; then they can consider changing it (2002, p. 97f). One could say that the reward in itself is a victim of the dominating culture that values research over teaching.

The final view, *change by leverage from external agencies*, could be regarded as another way of trying to force change on the departments, namely through external funding practices, and through institutions that control accreditation or central evaluation systems. These accreditation institutions frequently have a quite conservative

influence on curriculum and teaching in SMT, Seymour claims, but if they took a deliberate stance to improve new teaching and learning formats it might have an impact on the teaching and the curriculum on a larger scale, in addition to the limited number of programmes that get funding for developing teaching.

The seven theories or views of change presented by Seymour all suggest that changes cannot be expected to come from inspired and inspiring individuals or groups of teachers alone. It requires that the institutions and the management take a stance on the issue of the development of teaching and learning. Moreover, the views make it clear that if the cultural dimensions are neglected, and teaching is merely regarded as a technical matter, important issues will not be addressed. In this sense, without actually expressing it explicitly, Seymour touches upon another dimension that the review shows is of importance: who or what is considered as being the problem and who or what is expected to change?

Individual adaptation or institutional change?

In the concluding chapter of his book Tinto writes:

> The answer to the question of student retention which we offer is not simple. […] It springs from the ongoing commitment of an institution, of its faculty and staff, to the education of its students. But such commitment requires institutional change. It requires that institutions rethink traditional ways of structuring collegiate learning environments and find new ways of actively involving students, as well as faculty, in their intellectual life. It requires a deeper understanding of the importance of educational community to the goals of higher education (1993, p. 212).

By this, he touches upon an important issue that underlies the issue of retention, namely whether the problems are fundamentally regarded as a deficit with the students who are unable to adapt and submit to the requirements of the university, or are seen as an inability of the institution to meet the knowledge and expectations of the students. The suggestions of Yorke and Longden (2004) reported above, do not necessarily call for fundamental changes within the universities, but they do imply changes in priorities and conceptions of teaching. In an article on learning communities Tinto sums up:

> What are the implications of these findings for organizational reform? How might colleges and universities be organized if they took these findings on student persistence seriously and used them as guides for their educational reform efforts? Let me suggest several organizational reforms that would follow. First, colleges and universities would adopt a community model of academic organization that would promote involvement through the use of shared, connected learning experiences among its members, students and faculty alike. Second, colleges and universities, four-year ones in particular, would reorganize the first year of college as a distinct unit with its own underlying logic and pedagogical orientation. Third, colleges and universities would reorganize faculty work to allow them, as well as their students, to cross the disciplinary and departmental borders that now divide them. (Tinto, 1998, p. 170)

This programme for change is more radical than what is suggested in most articles and books on the issue. It calls for an entirely different way of thinking about the organisation of the university where the dominant pedagogical model would be different and the organisation of the teaching would not necessarily follow the traditional division of the disciplines. Interestingly, two Danish universities (the universities of

Roskilde and Aalborg) have more or less had these characteristics since they were founded in the beginning of the 1970s, but they have also experienced pressure from the outside world to adjust to a conventional structure. The most extensive experiment has been (and is) in Roskilde where students spend the first two years of study in one of three interdisciplinary basic study programmes (humanities, social sciences or natural sciences), and after that choose a specialisation in (usually) two disciplines. The pedagogical model has the students working mostly in groups on open problems (problem-oriented project work) which can be considered a kind of inquiry learning. The groups all have a teacher allocated as academic supervisor, according to the topic they are working on. In addition to the projects, students attend more conventional courses within disciplinary topics. The courses now take up at least half the teaching activities, but the projects are still the more prominent pedagogical format at the programmes. This model has been criticised and challenged by, for instance, national evaluation and accreditation boards, because it does not comply with disciplinary borders and conventions, and therefore students from these studies are considered less qualified.

We have made this brief digression to point at both some difficulties in applying a programme like that suggested by Tinto (but also showing that it has indeed been done) and to point at an issue that is left almost untouched in the discussion so far, namely the notion of the academic field as a field for power struggle. Both Harvey et al. (2006, p. 33) and Yorke and Longden (2004, p. 80) refer to a Bourdieu-inspired approach emerging in the field, applying the concepts of cultural and social capital and of habitus. However, as referred to in the discussion of critical perspectives on Tinto's model, it seems that the central social field as an area of struggle for power and position, is not that visible in these discussions of Bourdieu. The focus of many applications of Bourdieu's work is on the unequal distribution of cultural and social capital that provides the students with uneven possibilities of acting and succeeding in the field of academia, and on the habitus that means that the students are more or less well disposed for entering the game at the university. Of course, those are two important points. However, when it comes to analysing the potential for change and the possible measures that could be taken to increase retention, it is necessary to consider that capital and habitus are linked to the issue of acquiring and keeping more privileged and dominant positions in the field, both within the disciplines and between disciplines (Bourdieu, 1984, 1990). From Bourdieu's point of view the non-completion rates and the significant social bias shown within this (Pascarella & Terenzini, 2005; Thomsen, 2008) is not to be considered an unfortunate side effect of unequal resources – it is a way of the more privileged classes remaining in their more privileged position.

This power struggle also has an impact on the possibilities and difficulties of educational change. The experiences of the universities of Roskilde and Aalborg relate to the struggle for power and control of what is regarded as legitimate knowledge and procedures in the different disciplines. Attempts at changing these boundaries are basically a challenge to the power balance (cf. Bernstein, 2000). From this perspective, institutional change in order to accommodate students' experiences and difficulties is not simply a question of whether 'the academic level' of the course is compromised; for those holding dominant positions in the disciplinary community it appears as a threat to what is considered as the discipline itself. For those within the dominant culture of the discipline, the situation is not seen as a struggle for power in which some students are included and others excluded. To them it is simply a matter of defending what they consider to be the quality of the only right way to teach and

learn the discipline in question. Accommodating new courses in order to increase student retention will from this point of view threaten what the teaching seeks to accomplish.

This is the point made by Seymour (2002) stating that what is considered to be the universal standard of science is hard to question. It is a point similar to that made by Walker (2001) where the students did not acknowledge gender as an issue and because of this could not discuss or reflect on experiences related to gender differences. In the same way the fact that disciplines are not nature-given entities, but in fact are changeable, remains obscured, partly because culture is difficult to change, and partly because it serves to keep the existing division of influence and power.

Still, the research regarding student retention and success in higher education points in the direction of not merely providing students with a range of supplementary services (even if that is also relevant and can contribute to increased student retention, cf. Swanson (2006) and Harvey et al. (2006)). To fundamentally address the issue of enhancing student success it is not sufficient to try to adjust the students to the way the institutions are now. An institutional or organisational change is essential to a more substantial change. The question is however if that will be possible.

Conclusion and implications for further research

In this paper we have reviewed research on students' dropping or opting out of higher education in general and from STM studies in particular. The reviewed research on retention and non-continuation of students across different disciplines shows that there is no one factor determining student success. Instead, whether students persist or not is influenced by a number of factors and how these different factors interact.

The student's social and economic background and the reasons and processes behind the student's choice of study have an impact, as does the induction into the study programme. Students' preparation for their studies influence persistence, but students' academic level and abilities cannot explain why some students persist and others opt out. Conversely, the teaching and learning environment and the teaching methods applied prove to be highly important. The teaching and learning activities students are engaged in, the design of the curriculum and the interaction with faculty and peers are also important.

In a substantial part of the research included in this review, the problem of retention is being framed as located in either the student or located in the institution, respectively. However, another research approach to retention highlights the issue of identity construction and of being recognised as a legitimate member of the group of 'science people'. The inclusivity of the study environment and the disciplinary culture provides possible positions for the students to take, and makes some identities more legitimate and recognisable than others. Apparently, the STM culture is still to a large extent distinguished as being competitive, detached, white and male dominated. Students who for one reason or another (for instance gender, ethnic origin or the part of the discipline the student takes interest in) differ from what is considered normal within the field will often have more difficulties in being socially and academically integrated, and in developing an identity as one belonging to the discipline.

Suggestions of how to increase retention within the field of science education tend to focus on adjusting the students and leaving the institutional or disciplinary side stable and untouched. A few papers move in the direction of organisational change,

where the study programmes and the teaching and learning activities are adjusted according to students' background and experiences, but these kinds of measures risk being rejected because they are considered to be detrimental to the quality of the study programmes, as described in Seymour (2002). This claim, that the disciplines are stable and also objective entities with a fixed curriculum leads any suggestions of changing the curriculum to be regarded as a setback for the science discipline and student achievement. If the discipline is not regarded as an object of negotiation, the point of departure for changing drop out must be the students. This perspective makes it very difficult to introduce any measures that challenge the identity problem.

Firstly, this provides an explanation for why so few studies have followed the research ideas set out by Seymour and Hewitt (1997). In their work, they rejected the idea that the problem should be located in the student and instead framed it in relation to the match between the institutions and the students. We find that this is one of the prime reasons why it is so difficult to really address the problem of retention in science education. Science educators often demand a retention check list that can be imposed without changing the existing framework for teaching and the faculties' relation to the students. Evidently, these are precisely factors that according to research focusing on identity and the relation between students and institutions need to be addressed. Further, it is likely that this is the reason why some research addresses this highly complex problem of retention by focusing on the straightforward variables of students' behaviour and capabilities.

Secondly, it makes it even more urgent to further develop research into the culture(s) of science disciplines and science programmes, in the formation of identity during the study, and to expand the scope of this research to all groups of students – not just the minority groups, but also the dominant white male culture. This approach further suggests that the problem of retention should be rephrased from focusing on how to adjust the students so that they can meet the requirements of the existing science programme to a broader perspective on students' experiences with studying science, where not least the question is of how STM programmes can become part of students' identity formation. Will it be possible for STM programmes to convince future and present students that being integrated into an STM discipline is an attractive perspective for a young individual trying to find out who she or he is, and what direction her or his life should take?

Thirdly, there is a need to combine research addressing identity issues with pedagogical research approaches that address for instance the purpose and objectives of science studies, what content is included and what is excluded in science programmes and the teaching and assessment formats of the study programmes. Future research as well as future initiatives in higher education institutions addressing the opting or dropping out of students therefore needs to adopt a broad perspective on both the teaching and learning activities, and on the possible identities made available to students. However, what from our perspective stands out as perhaps the most important finding in this review is that a substantial part of the measures that could be taken to increase student retention do not necessarily go well with the self-conception, culture and tradition of STM disciplines and environments. Consequently, if STM programmes and institutions genuinely wish to increase the number of students completing the STM programme they enter, these programmes need to turn their focus from the students alone and on to themselves and the culture and values that are revered there, and consider whether they are perhaps a part of the problem. In our view, this is indeed most likely the case.

Notes

1. The paper is based on research that is part of IRIS (Interests and Recruitment in Science), a EU FP 7 project involving researchers from Norway (University of Oslo), the UK (University of Leeds and King's College London), Italy (Associazione Observa), Slovenia (University of Ljubljana) and Denmark (University of Copenhagen). The project is coordinated by the University of Oslo.

Notes on contributors

Lars Ulriksen is an associate professor at the Department of Science Education at University of Copenhagen. His recent publication "The implied student"; was published in *Studies in Higher Education*. 2009; Vol. 34, No. 5, August, pp. 517–532. His research field is science education at higher education in general and students' transition process from upper secondary school in particular. At the moment Lars Ulriksen is involved in the teacher training of the staff at the Faculty of Science at the University of Copenhagen, as well as the EU-funded international project IRIS (Interests & Recruitment In Science).

Lene Møller Madsen is an associate professor at the Department of Science Education at University of Copenhagen. Her recent publication "Implications of doing insider interviews: studying geography and geographers" was published in *Norsk Geografisk Tidsskrift* 2009; Vol. 93, No. 3, pp. 145–153. Lene's research focuses on students' interaction with science education at the higher education level and more specifically, geography education. Furthermore, Lene Møller Madsen is involved in teacher training of the staff at the Faculty of Science at the University of Copenhagen, as well as the EU-funded international project IRIS (Interests & Recruitment In Science).

Henriette T. Holmegaard is a PhD-student at the Department of Science Education at University of Copenhagen. In her research she focuses on students' choice of science and technology at the higher education level and more specifically, students' transition to science and technology related study programmes. In her PhD work, Henriette Tolstrup Holmegaard explores the interaction between students' identity construction and their meeting with these programmes and how this interaction relates to students' integration and retention at university.

References

Archer, L., DeWitt, J., Osborne, J., Dillon, J., Willis, B., & Wong, B. (2010). 'Doing' science versus 'seing' a scientist: Examining 10/11-year-old school children's constructions of science through the lens of identity. *Science Education 2010*, Published Online: 21 Apr 2010. DOI: 10.1002/sce.20399

Ariadurai, S.A., & Manohanthan, R. (2008). Reasons for student discontinuation in engineering degree courses offered at a distance. *Turkish Online Journal of Distance Education, 9*(3), 74–86.

Becher, T. (1989). *Academic tribes and territories: Intellectual enquiry and the cultures of disciplines.* Buckingham: The Society for Research into Higher Education & Open University Press.

Becher, T., & Trowler P.R. (2001). *Academic tribes and territories* (2nd ed.). Maidenhead: The Society for Research into Higher Education & Open University Press.

Bernstein, B. (2000). *Pedagogy, symbolic control and identity. Theory, research, critique.* Lanham: Rowman & Littlefield Publishers Inc.

Biggs, J., & Tang, C. (2007). *Teaching for quality learning at university* (3rd ed.). Maidenhead: Open University Press/McGraw Hill.

Bourdieu, P. (1984). *Distinction: A social critique of the judgement of taste.* London, Melbourne and Henley: Routledge & Kegan Paul.

Bourdieu, P. (1986). The Forms of Capital. In J.G. Richardson (Ed.), *Handbook of theory and research for the sociology of education,* (pp. 241–258). New York, Westport (Connecticut), London: Greenwood Press.

Bourdieu, P. (1990). *Homo academicus.* Cambridge: Polity Press.

Braxton, J., Milem, J.F., & Sullivan, A.S. (2000). The influence of active learning on the college student departure process: Towards a Revision of Tinto's Theory. *The Journal of Higher Education 71*, 569–590.

Braxton, J., Sullivan, A.V.S., & Johnson Jr., R.M. (1997). Appraising Tinto's theory of college student departure. In J.C. Smart (Ed.), *Higher Education: Handbook of theory and research. Volume XII* (pp. 107–164). New York: Agathon Press.

Butler, J. (1990). *Gender trouble: Feminism and the subversion of identity.* London: Routledge.

Carlone, H.B., & Johnson, A. (2007). Understanding the science experiences of successful women of color: Science identity as an analytic lens. *Journal of Research in Science Teaching, 44*(8), 1187–1218.

Cox, A., & Fisher, M. (2008). A qualitative investigation of an all-female group in a software engineering course project. *Journal of Information Technology Education, 7*, 1–20.

Croft, A.C., Harrison, M.C., & Robinson, C.L. (2009). Recruitment and retention of students: An integrated and holistic vision of mathematics support. *International Journal of Mathematical Education in Science and Technology, 40*(1), 109–125.

Crossley, M.L. (2000). Narrative psychology, trauma and the study of self/ identity. *Theory & Psychology, 10*, 527–546.

Daempfle, P.A. (2003). An analysis of the high attrition rates among first year college science, math and engineering majors. *Journal of College Student Retention, 5*(1), 37–52.

Davies, B. (2000). *A body of writing, 1990–1999.* Walnut Creek: AltaMira Press.

Davis, K.S. (2001). 'Peripheral and subversive': Women making connections and challenging the boundaries of the science community. *Science Education, 85*(4), 368–409.

DeHaan, R.L. (2005). The impending revolution in undergraduate science education. *Journal of Science Education and Technology, 14*(2), 253–269.

DesJardins, S.L., & Moye, M.J. (2000, May). *Studying the timing of student departure from college.* Paper presented at the Annual Forum for Association for Institutional Research (AIR), (40th), Cincinnati, Ohio, US, May 21–23. AIR grant invited paper.

Dyer, J.E., Breja, L.M., & Wittler, P.S.H. (2002). *Predictors of student retention in colleges of agriculture.* Proceedings of the 27th Annual National Agricultural Education Research Conference, San Diego.

Estaville, L.E., Brown, B.J., & Caldwell, S. (2006). Geography undergraduate program essentials: Retention. *Journal of Geography, 105*(2), 47–52.

Fenske, R.H., Porter, J.D., & DuBrock, C.P. (2000). Tracking financial aid and persistence of women, minority, and needy students in science, engineering and mathematics. *Research in Higher Education, 41*(1), 67–94.

Fenwick-Sehl, L., Fioroni, M., & Lovric, M. (2009). Recruitment and retention of mathematics students in Canadian universities. *International Journal of Mathematical Education in Science and Technology, 40*(1), 27–41.

Ferreira, M. (2003). Gender issues related to graduate student attrition in two science departments. *International Journal of Science Education, 25*(8), 969–989.

Fishman, S., & Decandia, L. (2006). Facilitating student and staff success. *College Quarterly, 9*(2).

Gergen, K. (1991). The saturated self. Dilemmas of identity in contemporary life. New York: Basic Books.

Gerholm, T. (1990). On tacit knowledge in academia. *European Journal of Education, 25*(3), 263–271.

Harris, G., Froman, J., & Surles, J. (2009). The professional development of graduate mathematics teaching assistants. *International Journal of Mathematical Education in Science and Technology, 40*(1), 157–172.

Harvey, L., & Drew, S., with Smith, M. (2006). *The first-year experience: A review of literature for the Higher Education Academy.* Higher Education Academy. http://www.heacademy.ac.uk

Hasse, C. (2002). *Kultur i bevægelse – fra deltagerobservation til kulturanalyse – i det fysiske rum* [Culture on the move – from participant observation to cultural analysis – in the physical space]. Frederiksberg: Samfundslitteratur.

Hazari, Z., Tai, R.H., & Sadler, P.M. (2007). Gender differences in introductory university physics performance: the influence of high school physics preparation and affective factors. *Science Education, 91*, 847–876.

Heublein, U., Schmelzer, R., & Sommer, D. (2008). *Die Entwicklung der Studienabbruchquote an den deutschen Hochschulen. Ergebnisse einer Berechnung des Studienabbruchs af der Basis des Absolventenjahgangs 2006.* [The development of student drop-out in the German higher education system. Results from an analysis of the non-completion based on the cohort of 2006.] HIS:Projektbericht. Hannover: HIS (Hochschul-Informations-System GmbH). (http://www.bildungsserver.de/zeigen.html?seite=4605) (accessed 30 May 2010).

Holland, D., Lachicotte Jr, W., Skinner, D., & Cain, C. (1998). *Identity and agency in cultural worlds.* Cambridge, MA and London: Harvard University Press.

Hovdhaugen, E. (2009). Transfer and dropout: Different forms of student departure in Norway. *Studies in Higher Education, 34*(1), 1–17.

Hsu, P., & Roth, M. (2009). To be or not to be? Discoursive resources for (dis-)identifying with science-related careers. *Journal of Research in Science Teaching 46*, 1114–1136.

Huber, L. (1991). Sozialisation in der Hochschule. [Socialisation in higher education] In K. Hurrelmann & D. Ulich, (Eds.): *Neues Handbuch der Sozialisationsforschung* (4th edition) (pp. 417–441). Weinheim und Basel: Beltz Verlag.

Hughes, G. (2001). Exploring the availability of student scientist identities within curriculum discourse: An anti-essentialist approach to gender-inclusive science. *Gender and Education, 13*(3), 275–290.

Hurtado, S., & Carter, D.F. (1997). Effects of college transition and perceptions of the campus racial climate on Latino college students' sense of belonging. *Sociology of Education, 70*(October), 324–345.

Ishitani, T.T. (2003). A longitudinal approach to assessing attrition behavior among first-generation students: Time-varying effects of pre-college characteristics. *Research in Higher Education, 44*(4), 433–449.

Jamelske, E. (2009). Measuring the impact of a university first-year experience program on student GPA and retention. *Higher Education, 57*(3), 373–391.

Keynes, H.B., Olson, A., Shaw, D., & Wicklin, F.J. (1999). Redesigning the calculus sequence at a research university. *Contemporary Issues in Mathematics Education, 36*, 57–65.

Malone, K.R., & Barabino, G. (2009). Narrations of race in STEM research settings: identity formation and its discontents. *Science Education, 93*, 485–510.

Mastekaasa, A., & Smeby, J-C. (2008). Educational choice and persistence in male- and female-dominated fields. *Higher Education, 55*, 189–202.

Mills, C., Heyworth, J., Rosenwax, L., Carr, S., & Rosenberg, M. (2009). Factors associated with the academic success of first year health science students. *Advances in Health Sciences Education, 14*, 205–217.

Nikola, U., Sajaniemi, J., Tedre, M., & Wray, S. (2007). Python and roles of variables in introductory programming: experiences from three educational institutions. *Journal of Information Technology Education, 6*, 199–214.

Organisation for Economic Co-operation and Development (OECD). (2008). *Encouraging student interest in science and technology studies.* Global Science Forum. Paris: OECD.

Organisation for Economic Co-operation and Development. (2009). *Education at a glance. OECD indicators.* http://www.oecd.org/dataoecd/41/25/43636332.pdf (accessed 16 February 2010)

Ozga, J., & Sukhnandan, L. (1998). Undergraduate non-completion: Developing an explanatory model. *Higher Education Quarterly, 52*(3), 316–333.

Pascarella, E.T., & Terenzini, P.T. (2005). *How college affects students. Volume 2. A third decade of research.* San Francisco, CA: Jossey-Bass.

Pokorny, M., & Pokorny, H. (2005). Widening participation in higher education: Student quantitative skills and independent learning as impediments to progression. *Journal of Mathematical Education in Science and Technology, 36*(5), 445–467.

Ronco, S.L., & Cahill, J. (2004, May). *Does it matter who's in the classroom? Effect of instructor type on student retention, achievement and satisfaction.* Paper presented at the 44th Annual Forum of the Association for Institutional Research, Boston, MA, US, May 2004.

Sarbin, T.R. (1986). *Narrative psychology. The storied nature of human conduct.* Wesport, CT: Praeger Publishers.

Schreiner, C. (2006). *Exploring a ROSE-garden. Norwegian youth's orientations towards science: Seen as signs of late modern identities.* (Doctoral thesis, University of Oslo, Norway). Series of dissertations submitted to the Faculty of Education, University of Oslo, no. 58. Oslo.

Schreuders, P.D., Mannon, S.E., & Rutherford, B. (2009). Pipeline or personal preference: Women in engineering. *European Journal of Engineering Education, 34*(1), 97–112.

Seymour, E. (2002). Tracking the processes of change in US undergraduate education in science, mathematics, engineering, and technology. *Science Education, 86*(1), 79–105.

Seymour, E., & Hewitt, N.M. (1997). *Talking about leaving: Why undergraduates leave the sciences.* Boulder, CO: Westview Press.

Singh, K., Allen, K.R., Scheckler, R., & Darlington, L. (2007). Women in computer-related majors: A critical synthesis of research and theory from 1994 to 2005. *Review of Educational Research, 77*(4), 500–533.

Soh, L., Ashok, S., & Nugent, G. (2007). An integrated framework for improved computer science education: Strategies, implementations, and results. *Computer Science Education, 17*(1), 59–83.

Sorensen, K.H. (2000, March). *Factors influencing retention in introductory biology curriculum.* Paper presented at the Annual Meeting of the National Association for Research in Science Teaching, Boston, MA, US, March 28–31, 1999.

St. John, E.P., Shouping, H., Simmons, A., Carter, D.F., & Weber, J. (2004). What difference does a major make? The influence of college major field on persistence by African American and white students. *Research in Higher Education, 45*(3), 209–232.

Stentoft, D., & Valero, P. (2009). Identities-in-action. *Nordic Studies in Mathematics Education, 14*(3), 55–77.

Swanson, D.J. (2006, April). *Creating a culture of 'engagement' with academic advising: Challenges and opportunities for today's higher education institutions.* Paper presented in the 'Sociology and Anthropology' section, Panel 8: Engaging the Ivory Tower. Western Social Science Association convention, April 21, 2006, Phoenix, AZ.

Søndergaard, D.M. (1996). *Tegnet på kroppen* [The Sign on the Body]. Copenhagen: Museum Tusculanums Forlag.

Tate, E.D., & Linn, M.C. (2005). How does identity shape the experiences of women of colour engineering students? *Journal of Science Education and Technology, 14*(5/6), 483–493.

Taylor, Stephanie. (2009). *Narratives of identity and place.* East Sussex and New York: Routledge.

Thomsen, J.P. (2008). *Social differentiering og kulturel praksis på danske universitetsuddannelser* [Social differentiation and cultural practice at Danish university programmes]. (Doctoral thesis – Graduate School in Lifelong Learning, Department of Psychology and Educational Studies, Roskilde University). Roskilde: Graduate School in Lifelong Learning.

Tierney, W.G. (1999). Models of minority college-going and retention: cultural integrity versus cultural suicide. *Journal of Negro Education, 68*(1), 80–91.

Tinto, V. (1975). Dropout from higher education: A theoretical synthesis of recent research. *Review of Educational Research, 45*(1), 89–125.

Tinto, V. (1988). Stages of student departure: Reflections on the longitudinal character of student leaving. *Journal of Higher Education, 59*(4), 438–455.

Tinto, V. (1993). *Leaving college: Rethinking the causes and cures of student attrition* (2nd ed.). Chicago and London: The University of Chicago Press.

Tinto, V. (1997). Classrooms as Communities: Exploring the Educational Character of Student Persistence. *The Journal of Higher Education 68*(6), (November–December), 599–623.

Tinto, V. (1998). Colleges as communities: Taking research on student persistence seriously. *The Review of Higher Education, 21*(2), 167–177.

Tobin, K., & Roth, W-M. (Eds.). (2007). *Science, learning, identity: Sociocultural and cultural-historical perspectives.* Rotterdam, NL: Sense Publishers.

Turner, P.R. (2008). A predictor-corrector process with refinement for first-year calculus transition support. *PRIMUS, 18*(4), 370–393.

Walker, M. (2001). Engineering identities. *British Journal of Sociology of Education 22*(1), 75–89.

Wasburn, M.H., & Miller, S.G. (2004–2005). Retaining undergraduate women in science, engineering, and technology: A survey of a student organization. *Journal of College Student Retention, 6*(2), 155–168.
Wetherell, M. (Ed.) (2009). *Theorizing identities and social action.* Basingstoke: Palgrave Macmillan.
White, J.L., Altschuld, J.W., & Lee, Y. (2006). Cultural dimensions in science, technology, engineering and mathematics: Implications for minority retention research. *Journal of Educational Research & Policy Studies, 6*(2), 41–59.
Wischusen, S.M., & Wischusen, E.W. (2007). Biology intensive orientation for students (BIOS): A biology 'boot camp'. *CBE – Life Sciences Education, 6*, 172–178.
Wood, S.L. (2002, April). *Becoming a woman engineer in the community of practice: Validity and value in engineering-education research.* Paper presented at the Annual Meeting of the American Educational Research Association, New Orleans, LA, US, April 1–5, 2002.
Xu, Y.J. (2008). Gender disparity in STEM disciplines: A study of faculty attrition and turnover intentions. *Research in Higher Education, 49*(7), 607–624.
Yan, W. (2002). *Postsecondary enrolment and persistence of students from rural Pennsylvania.* Harrisburg, PA: The Centre for Rural Pennsylvania.
Yorke, M., & Longden, B. (2004). *Retention and student success in higher education.* Maidenhead, UK: Open University Press.